METHODS OF SAMPLING AND TESTING
MT 332-04
GYRATORY COMPACTION OF BITUMINOUS MIXTURES
(*MONTANA TEST METHOD*)

1 Scope:

1.1 Verification of asphalt content and mixture properties of bituminous mixtures by the compaction of cylindrical specimens of hot mix asphalt (HMA) using the Superpave gyratory compactor. The density of bituminous mixtures is determined directly for Ndesign.

2 Referenced Documents:

2.1 ***AASHTO:***

M 231 Weighing Devices Used in the Testing of Materials
PP 48 Evaluation of the Superpave Gyratory Compactors (SGC) Internal Angle of Gyration

MT Manual:

MT-314 Method of Test for Bulk Specific Gravity of Compacted Bituminous Mixtures
MT-321 Procedure for Determining Maximum Specific Gravity of Bituminous Paving Mixtures – "Rice Method"

3 Process Description:

3.1 It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3.2 A sample is placed into a 150 mm mold for an apparatus that compacts bituminous mixture using a combination of pressure and gyration. The apparatus measures the specimen height very precisely as compaction occurs after each gyration. The required compaction effort is defined from tables found in the specifications. This procedure is intended to show how closely the bituminous mixture being produced is to the production requirements.

4 Significance and Use:

4.1 This procedure is used to prepare specimens for determining the volumetric properties of HMA.

5 Apparatus:

5.1 *Superpave Gyratory Compactor* - An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 5.3 that are restrained from revolving during compaction. The axis of the ram shall be perpendicular to the platen of the compactor. The ram shall apply and maintain a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction. The compactor shall tilt specimen molds at an average internal angle of 1.16 ± 0.02 degrees (Note 1). The equipment shall gyrate specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

*Note 1 – For most equipment this equates to an external angle of 1.*25 ± *0.02 degrees.*

5.1.1 *Specimen Height Measurement and Recording Device* - When specimen density is to be monitored during compaction, a means shall be provided to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction; once per gyration.

5 Apparatus: (continued)

5.1.2 The system may include a printer connected to an RS232C port capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

5.2 *Specimen Molds* - Specimen molds shall have steel walls that are at least 7.5 mm thick hardened to at least Rockwell C48. The inside of the molds shall be smooth (Note 2). Molds shall have an inside diameter of 149.90 to 150.00 mm and be at least 250 mm high at room temperature.

Note 2 - Smooth is measured in accordance with ANSI B46.1 with rms value of 1.60 µm or less.

5.3 *Ram Heads and Mold Bottoms* - Ram heads and mold bottoms shall be fabricated from steel with a minimum Rockwell hardness of C48. The ram heads shall stay perpendicular to its axis. The platten side of each mold bottom shall be flat and parallel to its face. All ram and base plate faces (the sides presented to the specimen) shall be flat to meet smoothness requirement in 5.2 (Note 2) and shall have a diameter of 149.50 to 149.75 mm.

5.4 *Thermometers* - Armored, glass, thermal reading or dial-type thermometers with metal stems for determining temperature of aggregates, asphalt and asphalt mixtures between 10º C to 232º C.

5.5 *Balance* - a balance meeting the requirements of M231, Class G5, for determining the mass of aggregates, binder and HMA.

5.6 *Oven* - An oven, thermostatically controlled to ± 3º C, for heating aggregates, binder, HMA and equipment as required. The oven shall be capable of maintaining the compaction temperature range.

5.7 *Miscellaneous* - flat bottom metal pans of at least 500 square inches that are square or rectangular for heating plant mix and that will accommodate quartering. Scoop to remove mixture quarters for testing. Large spatula for turning and mixing sample prior to quartering. "Insulated gloves, a lab apron or coat and other safety equipment as necessary. Lubricating materials recommended by compactor manufacturer and assorted cloth and paper rags for wiping molds and other surfaces. A Gyro Loader (a trough) is optional for adding samples to the mold.

6 Standardization:

6.1 Items requiring periodic verification of calibration include the ram pressure, the angle of gyration, the gyration frequency, the LVDT (or other means used to continuously record the specimen height) and oven temperature. Verification of the mold and platen dimensions are also required. When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes. Verification of calibration, system standardization and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. **Frequency of verification shall follow manufacturer's recommendations.**

6.2 The angle of gyration may refer to either the external angle (tilt of mold with respect to a plane external to the gyratory mold) or the internal angle (tilt of the mold with respect to end plate surface within the gyratory mold). Procedures used to verify the calibration of the angle of gyration must be appropriate for measuring the angle desired.

Note 3 – The two methods (Method A – external and Method B – internal) of verifying the calibration of the gyration angle should NOT be considered equivalent. The gyration angle for all SGCs in a group for which compaction results are to be compared should be verified using the same method.

6.2.1 *Method A* – The calibration of the external angle of gyration should be verified using the manufacturer's recommendations for the appropriate SGC

6.2.2 *Method B* – The calibration of the internal angle of gyration should be verified in accordance with AASHTO PP 48.

7 Materials:

7.1 Approximately 22,000 grams of plant mix are required to perform all of the required tests, including fabrication of two gyratory specimens.

8. Preparation of Apparatus:

8.1 Lubricate any surfaces as required by the Manufacturer.

8.2 Turn on the main power for the compactor for the manufacturer's required warm-up period. Verify machine settings are correct for angle, pressure and number of gyrations.

Note 4 - The required number of gyrations are shown in the Special Provisions.

8.3 Turn on the device for measuring and recording the height of the specimen and verify that the readout is in the proper units, mm, and that the recording device is ready and, if used, prepare the computer to record the height data and enter the header information for the specimen.

9 Asphalt Specimen Fabrication:

9.1 The batch weights will be adjusted to result in a compacted specimen having dimensions of 150 mm in diameter and 115 ± 3 mm in height at the designed number of gyrations. Plant mix that is brought to the test location and is still within the compaction temperature range may be batched for immediate testing. Loose HMA plant mix below the compaction temperature range shall be brought to the compaction temperature range by careful uniform heating in an oven immediately prior to molding. Heating proceeds more quickly if the sample is placed in a clean (buttered) flat bottomed pan. Loose mix that is at a temperature within the compaction temperature range should not be reheated.

10 Compaction Procedure:

10.1 Place a compaction mold and base plate in an oven at the required compaction temperature for to pre-heat mold and base plate to compaction temperature prior to the estimated beginning of the compaction cycle. When the bituminous mixture is within the compaction temperature range, remove the heated mold and base plate from the oven and place a paper disc in the bottom of the mold.

Note 5 – It is recommended to compact test specimens at a constant temperature.

10.2 Pour the pre-weighed quantity of bituminous mixture into the mold in one lift. The use of the gyro loader will facilitate this operation. If you do not have a gyro loader, another method that has worked is to pour the sample from a paper bag that has been filled with proper weight of bituminous mixture. The bag acts as a container and a funnel when filling the mold. Care should be taken to avoid segregation. Dump, don't trickle, the sample into the mold. Level the mix with the stroke of a spatula and place another paper disk on top of the leveled material. If using the Pine compactor, the top plate is inserted with the bevel up. See the operating manual for the equipment you have for more detailed instructions or another brand of compactor.

10.3 Center the mold under the loading ram. With the Pine machine, rotate the mold clockwise to the stop. Start the load compaction cycle. The machine will lower the ram until the pressure on the specimen reaches 600 kPa ± 18 kPa, apply a 1.25 ± 0.02º external angle to the mold assembly and begin the gyratory compaction.

10.4 Allow the compaction to proceed until the desired number of gyrations is reached and the ram retracts. Record the specimen height at Ndes. A printed record may be produced as the compactor operates. Remove the mold from the compactor and extrude the specimen from the mold.

10 Compaction Procedure: (continued)

Note 6 - Specimens may usually be extruded from the mold immediately. For lean, rich or tender mixtures, a cooling period of 5 to 10 minutes may be necessary before extruding the specimen to avoid having the specimen crumble.

10.5 Remove the paper disks from the top and bottom of the specimens. Write the specimen number on the specimen and on the gyration log sheet. Cool the specimens by placing them ahead of a fan or an air conditioner. Handle them carefully. Hot specimens are fragile.

Note 7 - Before reusing the mold, place it in an oven to reheat to compaction temperature range. The use of multiple molds will speed up the compaction process.

11 Density Procedure:

11.1 Determine the maximum specific gravity (G_{mm}) of the loose mix in accordance with MT-321 using a companion sample. The companion sample shall be aged to the same extent as the compaction sample.

11.2 Record the mass of the extruded specimen to the nearest 0.1 gram and determine the bulk specific gravity (Gmb) of the extruded specimen in accordance with MT-314. This is the bulk gravity of the specimen at Ndes. Measure the bulk density of the compacted bituminous mixture after the specimen has cooled sufficiently (slightly warm to touch, not hot) following MT-314.

% Air Voids (Va) Record and round to the nearest 0.1%.

$$Va = 100x\left(\frac{Gmm - Gmb}{Gmm}\right)$$

Gmm = maximum specific gravity of paving mixture (Rice)
Gmb = bulk specific gravity of compacted mixture

Voids in the Mineral Aggregate (VMA) Record and round to the nearest 0.1%.

$$VMA = 100 - \left(\frac{Gmb(100 - \%AC)}{Gsb}\right)$$

Voids Filled with Asphalt (VFA) Record and round to the nearest 1.0%.

$$VFA = 100x\left(\frac{VMA - Va}{VMA}\right)$$

Dust/Asphalt Ratio Record and round to the nearest 0.1%.

$$\frac{-200\%\,pass(MT-320)}{CorrectedAsphaltContent(MT-319)} = \_\_\_\_\_$$

Note 8 – The Dust/Asphalt ratio is to be used during mix design and field production.

11 Density Procedure:

Dust Proportion Record and round to the nearest 0.1%.

Effective Asphalt Content:

$$Pbe = -(PsxGb)x\frac{(Gse - Gsb)}{(GsexGsb)} + Pb \_\_\_\_\_ estimated$$

Pbe = effective asphalt content, percent by total mass of mixture
Ps = aggregate content, percent by total mass of mixture
Gb = specific gravity of asphalt
Gse = effective specific gravity of aggregate
Gsb = bulk specific gravity of aggregate
Pb = asphalt content, percent by total mass of mixture

Note 9 – The Dust Proportion is to be used during mix design.

Link to Excel spreadsheet

Form No. F400 B Q:\MT-STD\F400.doc
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GYRATORY DATA ENTRY FORM

Project No._____ Project Name_____

Date_____ Operator_____Title_____

Project _____Mix Design Number_____ Design Date_____

Bin %: Coarse_____ Intermediate _____fine_____

Bulk gravity of Coarse_____ Intermediate _____Fine _____ Bulk gravity of Blend_____

Source of AC _____ Grade of AC_____ Gravity of AC_____

Sample No.									AVGS.
% AC (spot check)									
Plant temperature									
Time sampled									
Mix temperature									
Time Tested									
Mass									
Height Ini. (H) i									
Height Des. (H) d									
Wt. In Air (a)									
Wt. In Water (c)									
SSD Wt. In Air (b)									

Gravities

AVGS									
Rice (Gmm.)									
Dsgn Bulk (Gmb) =a/(b-c)									
Initl Bulk (Ini Gmb) = Gmb x (H)d /(H)i									

Voids:

AVGS									
Dsgn.Vds (Va). = 100 – (Gmb/Gmm) x 100.									
Ini. Vds.=100– ini Gmb x 100 / Gmm									
VMA =100 –(Gmb) X 100 / Gmm									
VFA =100 –(VMA - Va)X100 / VMA									

Notes:

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